REMARKS

By the present amendment, claims 1-4, 6 and 8-16 are pending in the application. Claims 1-4 are independent claims.

SUPPORT FOR AMENDED CLAIMS

Claims 1 to 4

Independent claims 1 to 4 have been amended to specify that --the steel pipe is a water quenched steel pipe--.

Water quenching of the steel pipe of the present invention is disclosed in the specification, e.g., at page 7, lines 2 to 3; page 9, lines 6 to 7; page 9, lines 14 to 15; page 9, line 37 to page 10, line 3; and page 13, lines 29 to 31.

Independent claims 1 to 4 have been amended to change the upper limit of Si from "0.30%" to --0.27%--.

In independent claims 1 to 4, it is specified that the Si amount is controlled in a range from (Mn/8 – 0.07) to (Mn/8 + 0.07). Mn is specified as 0.5 to 1.60%. Therefore, the maximum Si specified by the equation is 1.60/8 + 0.7 = 0.27%. Therefore, the upper limit of Si in independent claims 1 to 4 has been made consistent the equation in independent claims 1 to 4 for controlling the Si amount.

Claim 14

Dependent claim 14 has been amended to change "the prior austenite grain size number" to --a prior austenite grain size number--.

§112,¶1

Claims 1 to 4, 6 and 8 to 16 were rejected under 35U.S.C.§112, first paragraph, as failing to comply with the written description requirement.

The Office Action maintains that the expressions "not more than 0.5% Cr" and "not more than 0.5% Mo" in claims 1 to 4 are not supported by the specification as originally filed.

The Office Action maintains that Cr in an amount greater than 0% and less than 0.005% is new matter and that Mo in an amount greater than 0% and less than 0.1% is new matter.

This rejection is respectfully traversed.

The Office Action recognizes that 0% Cr and 0% Mo is disclosed in the specification because Cr and Mo are disclosed as optional chemical elements in the steel composition of the steel pipe of the present invention.

The Office Action also recognizes that 0.005 to 0.5% Cr and 0.1 to 0.5% Mo are disclosed in the specification.

The Office Action takes a very narrow view that the specification only mathematically recites 0% and 0.005 to 0.5% Cr and 0% and 0.1 to 0.5% Mo.

The Office Action ignores the principle that the disclosure of the specification is directed to one skilled in the art and the disclosure of the specification is understood as it is understood by one skilled in the art.

The specification makes the following disclosure with respect to the optional Cr and Mo additions to the steel composition of the steel pipe of the present invention at page 8, lines 15 to 26.

> Cu, Cr, Mo and Ni are solid solution hardening components that enhance strength by dissolving in martensite crystals and thus preventing dislocations from passing through the dissolved components. Note that Cr and Mo function also as precipitation hardening components. Those components, thought they contribute to the enhancement of strength, cause the cost to increase and, moreover, form segregated inclusions when they are excessively added. Therefore, their appropriate amounts are 0.005 to 0.050% Nb, 0.005 to 0.07% V, 0.005 to 0.5% Cu, 0.005 to 0.5% Cr, 0.1 to 0.5% Mo and 0.1 to 0.5% Ni.

The specification clearly is teaching one skilled in the art that a minimum of 0.005% Cr and a minimum of 0.1% Mo are required in order to have their beneficial effects of enhancing strength and providing precipitation hardening. The specification is also clearly teaching that greater than 0.5% Cr and greater than 0.5% Mo are detrimental.

One skilled in the art would clearly understand the specification discloses that for the optional Cr or optional Mo, that greater than 0% but less than 0.005% Cr has no beneficial effect or that greater than 0% but less than 0.1% Mo has no beneficial effect.

Applicants maintain that the specification clearly teaches one skilled in the art that if the optional Cr or optional Mo is added to the steel composition of the steel pipe of the present invention, greater than 0% Cr but less than 0.005% Cr has no beneficial effect or greater than 0% Mo but less than 0.1% Mo has no beneficial effect. These ranges are clearly disclosed in the specifications.

The CCPA has made clear in *In Re Dinh-Nguyen and Stenhagen* 181 USPQ 46, 47 (CCPA 1974) that

> Any assertion by the Patent Office that the enabling disclosure is not commensurate in scope with the protection sought must be supported by evidence or reasoning substantiating the doubts so expressed.

The Office Action has provided no evidence or reasoning substantiating that the specification has not disclosed to one skilled in the art reading the specification information with respect to greater than 0% to less than 0.005% to Cr or with respect to greater than 0% to less than 0.1% Mo.

The CCPA has also made clear in In re Dinh-Nguyen and Stenhagen that is not the function of the claims to specifically exclude ineffective reactant proportions. See, 181 USPQ 46,48 (CCPA 1974).

> Disclosure in the *specification* sufficient to enable practice of the invention by one skilled in the art, taking into consideration obvious modifications of the reactant ratios of specific examples, is all that is

required. It is not a function of the *claims* to specifically exclude either possible inoperative substances or ineffective reactant proportions.

§112, ¶2

Claims 1 to 4, 6 and 8 to 16 were rejected under 35 U.S.C.§112, second paragraph, as being indefinite.

The Office Action maintains that claims 1 to 4 are indefinite because the Si content has two ranges.

In response to this rejection, claims 1 to 4 have been amended by the present amendment to specify that the upper limit of Si is --0.27%--.

Therefore, by the present amendment, the Si content of the steel composition of the present invention must meet two criteria which are not inconsistent with one another.

If Mn = 1.60%, then Mn/8+0.07 = 027% Si, which is the amended maximum amount of Si.

If Mn = 0.5%, Mn/8 – 0.07 = -0.0075% Si. Therefore, the lower limit of 0.10% Si places a second condition on Si, i.e., never lower than 0.10% Si. Conversely, if Mn is 1.60%, Si cannot be lower than Mn/8 – 0.07 = 0.13% Si, which is still within the range of 0.10 to 0.27% Si.

It is submitted that amended independent claims 1 to 4 places two criteria on Si which are not inconsistent.

Dependent claim 14 has been to recite --a prior--.

It is therefore respectfully requested that the rejection under 35 US.C. §112, second paragraph, be withdrawn.

Specification

The specification was objected to because pages 3, 4, 6, 7 and 11 contained reference to the claims.

By the present amendment, the specification has been amended to remove reference to the claims.

In view of the present amendment, it is respectfully requested that the objections to the specification be withdrawn.

<u>§103</u>

Claims 1, 6 and 8 to 10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Japan No. 6-179945.

Claims 1 to 4, 6 and 8 to 16 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No, 5,374, 322 to Okada *et al.*

These rejections, as applied to the amended claims, are respectfully traversed.

THE PRESENT INVENTION

The present invention is directed to the following combination of features.

1. A water quenched steel pipe having a defined composition.

2. A steel composition for the pipe which includes 0.5 to 1.60% Mn wherein the presence of Cr and Mo in the steel composition is arbitrary. That is the steel composition of the pipe can contain 0% Cr and 0% Mo. If Cr is present in the steel composition of the pipe of the present invention, the maximum Cr permitted is 0.5%. If Mo is present in the steel composition of the pipe of the present invention, the maximum Mo permitted is 0.5%.

3. The present invention has a low YR (yield ratio) in combination with a very high TS (tensile strength). The minimum tensile strength of independent claims 1 to 4 is as follows.

claim 1	-	1700 MPa	=	173.9 kgf/mm^2
claim 2	-	1800 MPa	=	183.5 kgf/mm^2
claim 3	-	1900 MPa	=	193.7 kgf/mm^2
claim 4	-	2000 MPa	=	203.9 kgf/mm^2

The conversion factor of 1 kgf/mm^2 = 9. 81 MPa or MPa/9.81 = kgf/mm^2 was used.

4. The very high TS of the present invention is the result of the claimed chemical composition of the steel of the pipe as set forth in independent claims 1 to 4 in combination with heat treating of the pipe followed by water quenching. Water quenching is particularly important. Induction heating is a disclosed preferred heat treatment.

The cooling rate of water quenching in approximately 100°C/sec (6,000°C/min) or higher, which results in the very high TS and low YR. Specification, page 9, line 37 to page 10, line 3. Fig. 2 of the specification of the present application illustrates

that water cooling (approximately 100°C/min or 6,000°C/sec or greater) has a very significant effect on yield ratio (YR) at 0.1% proof stress as compared to 0.2% proof stress.

The Examples of the present invention at Table 2, page 14 of the specification disclose water quenching cooling rates of 150 to 200°C/sec (9,000 to 12,000°C/min).

The water quenching causes an instantaneous transformation from austenite to martensite and the dislocation density in the martensite structure increases drastically. Specification, page 9, lines 14-19.

The high dislocation density caused by the water quenching lowers the yield point (YS) while a higher TS is maintained. Specification, page 9, lines 28-36. The dislocation density of the present invention is 10^{10} - 10^{14}/mm^{-2}.

5. The high tensile strength (TS) defined in independent claims 1 to 4 is the result of water quenching of the heat treated steel pipe having the steel composition defined in independent claims 1 to 4.

The water quenching of the present invention results in the high dislocation density of the present invention, 10^{10} - 10^{14}/mm^{-2}, which is set forth in dependent claim 6.

The high dislocation density of the present invention results in the high tensile strength (TS) of the present invention.

6. The cited prior art, JP 6-179945 ("JP '945") and U.S. Patent No. 5,374,322 ("US '322) does not disclose or suggest the steel pipe composition of claims 1 to 4.

7. The cited prior art, JP '945 and US '322, teaches air cooling, not water quenching. Air cooling provides a cooling rate of at most a few 100°C/min. Water quenching, in accordance with the present invention, provides a cooling rate of 6,000°C/min (100°C/sec) or higher. Specification, page 9, line 37 to page 10, line 3.

8. The cited prior art, JP '945 and US '322, does not disclose or suggest a steel pipe which has, <u>in combination</u>, (i) the steel composition defined in independent claims 1 to 4 <u>and</u> (ii) a tensile strength (TS) of 1700 MPa (173.9 kgf/mm^2) or higher.

9. The cited prior art, JP '945 and US '322, does not disclose or suggest a method to make a steel pipe defined in independent claims 1 to 4 because JP '945 and /or US '322 do not disclose or suggest a steel pipe having the composition required by independent claim 1 to 4 or water quenching a heat treated steel pipe having the composition required by independent claims 1 to 4 to obtain a steel pipe having a very high tensile strength (TS) of 1700 MPa or greater in combination with a low yield ratio (YR) required by independent claims 1 to 4. The present invention has both a very high tensile strength (TS) and a low yield ratio (YR).

CLARIFICATIONS - JP '945

The Japanese patent attorneys handling this case provided the following clarifications with respect to the disclosure of Japan No. 6-179945.

Table 1

Examples 1, 2 and 3 of Table 1 of JP '945 appearing at page 5 [0027] of JP '945 are comparative examples. Examples 4 to 18 of Table 1 of JP '945 are examples of the technology disclosed in JP '945. This also applies to Table 2 at page 6 [0028] of JP '945.

This information was not expressly included in the computer English translation of JP '945 provided by the PTO.

Table 2

The computer English translation of JP '945 provided by the PTO did not translate the headings of the columns of Table 2 (page 6 [0028]) of JP '945. The columns of Table 2 (page 6 [0028]) of JP '945 are directed to the following parameters.

Col. 1 - Example number.

Col. 2 - Hot rolling finishing temperature (°C).

Col. 3 - Coiling temperature (°C).

Col. 4 - Heat treatment temperature for ERW pipe.

Col. 5 - Cold working ratio (%).

Col. 6 - Final heat treatment for the cold worked pipe.

Col. 7 - Tensile strength (TS) of a steel plate prior to being manufactured into a pipe. Thus, in Example 1, Col. 7 of Table 2 discloses that a steel plate has a tensile strength (TS) of 125 kgf/mm^2 prior to being manufactured into a steel pipe.

Col. 8 - Tensile strength (TS) of the final steel pipe product. Thus, in Example 1, Col. 8 of Table 2 discloses that the final steel pipe product has a tensile strength of 152 kgf/mm^2.

Col. 9 - Elongation of the final steel pipe product (%).

Col. 10- Yield ratio (YR) of the final steel pipe product. Thus, in Example 1, Col. 10 of Table 2 discloses that the final Steel pipe product has a yield ratio (YR) of 0.80.

[0024]

In paragraph [0024] of JP '945, the cooling rate parameter is 10-150°C/min. The computer English translation states "10-150-degree-C/. The computer English translation does not translate the parameter as °C/min which appears in the original Japanese.

PATENTABILITY OVER PRIOR ART

Japan No. 6-179945

JP '945 is directed to a normalized, i.e., air cooled, steel pipe. The present invention is directed to a water quenched steel pipe.

There is no overlap in composition. JP '945 has a steel composition containing 2.0 to 3.0 wt% (or mass %) Mn. The steel composition of the present invention contains 0.5 to 1.60 mass % Mn. Therefore, the lowest Mn of JP '945 (2.0%) is 25% greater than the highest Mn of the present invention (1.60%). A 25% difference between lowest and highest is not insignificant.

The only example of JP '945 to attain a tensile strength of 1700 MPa (173.9 kgf/mm^2) or more (claim 1 of the present application) is Example 11 which has a tensile strength of 180 kgf/mm^2. Example 11 of JP '945 discloses a steel composition containing 2.50% Mn which is 56% greater than the maximum Mn (1.60%) of the present invention. Example 11 has a steel composition containing 1.0% Mo which is 100% greater than the maximum Mo (0.5%) of the present invention.

Thus, JP '945 requires a steel composition which is significantly different than the claimed steel composition of the present invention in order for JP '945 to attain a tensile strength of 1700 MPa (173.9 kgf/mm^2) required by claim 1 in accordance with the present invention.

JP '945 is significantly different than the present invention.

Composition and Cooling

JP '945 teaches a steel pipe which has a steel composition which contains 2.0 - 3.0 wt% (or mass %) Mn. See claims 1, 2 and [0013] of JP '945. The computer English translation of [0013] of JP '945 discloses that Mn is required in an amount of at least 2.0% or more in order to obtain a good reinforcement and ductility balance, raise the reinforcement and to secure elongation. In JP '945, claim 1 and the English abstract disclose a tensile strength (TS) of 150 to 180 kgf/mm^2, but this tensile strength is disclosed in <u>combination</u> with Mn in the range of 2.0 to 3.0 wt %, which is outside the Mn range of the present invention (0.5 to 1.60 mass % Mn).

In the computer translation of JP '945, [0006] is the Means For Solving The Problem. This is followed by [0007] of the computer translation which discloses 2.0 - 3.0 wt% (mass%) Mn, a Cr - Mo system and the organization of martensite and banite by <u>normalizing</u>. The English Abstract of JP '945 discloses the Title of JP '945 as "Chromium - molybdenum system, electric welded steel pipe ...". The English Abstract of JP '945 discloses 2.0 - 3.0% Mn and a structure of martensite and banite obtained by <u>normalizing</u>.

It is thus clear that 2.0 to 3.0% Mn is essential to the technology of JP '945. The present invention, defined in independent claims 1 to 4, is directed to 0.5 - 1.60% Mn.

JP '945 is directed to a Cr - Mo system. This technology of JP '945 is different from the present invention where Cr and Mo are arbitrary components of the steel composition.

JP '945 teaches <u>normalizing</u> or air cooling of the steel. See discussion above. The art understands normalizing to mean annealing followed by air cooling, particularly cooling in still air or natural cooling.

In the present invention, there is water quenching of the heat treated steel pipe. Water quenching results in a cooling rate of about 100°C/sec (6,000°C/min) or more which is very different from normalizing or air cooling which at most has a cooling rate of a few 100°C/min. The Examples of the present invention at Table 2, page 14 of the specification disclose water quenching cooling rates of 150 to 200°C/sec (9,000 - 12,000°C/min). As previously discussed, the water quenching of the present invention is directly related to the very high tensile strength (TS) of the present invention. The water quenching of the present invention results in the high dislocation density of 10^{10} to $10^{14}/mm^{-2}$ which is directly related to very high tensile strength (TS) and low yield rate (YR). See again specification page 9, line 14 to page 10, line 9.

Comparative Examples of JP '945

Comparative Examples 1 to 3 at Tables 1 and 2 of JP '945 disclose the following.

	Mn	Mo	Cr	TS
Ex. 1	1.30	2.0	0.5	152 kgf/mm^2
Ex. 2	1.60	0.5	2	155 kgf/mm^2
Ex. 3	1.60	1.5	0.0	155 kgf/mm^2

Comparative Examples 1 and 3 of JP '945 disclose 2.0% Mo or 1.5% Mo. This is outside the maximum permitted Mo of 0.5% specified in independent claims 1 to 4. Comparative Example 2 of JP '945 discloses 2% Cr. This is outside the maximum permitted Cr of 0.5% specified in independent claims 1 to 4.

Therefore, Comparative Examples 1, 2 and 3 of JP '945 do not disclose or suggest the steel pipe composition of the present invention defined in independent claims 1 to 4.

The minimum tensile strength (TS) claimed, in accordance with the present invention, is 173.9 kgf/mm^2 (1700 MPa) claimed in independent claim 1. Comparative Examples 1, 2 and 3 of JP '945 disclose tensile strengths of 152, 155 and 155 kgf/mm^2.

Comparative Examples 1, 2 and 3 of JP '945 do not disclose or suggest the steel composition of the present invention or a minimum tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) required by the present invention.

<u>Examples of JP '945</u>

The Examples of the technology of JP '945 are Examples 4 to 18 of Tables 1 and 2. All of Examples 4 to 18 of Tables 1 and 2 of JP '945 disclose Mn in a range of 2.0 to 3.0% Mn. This is outside the range of Mn claimed for the steel composition of independent claims 1 to 4 which claim 0.5 to 1.60 % Mn. The upper limit of 1.60 % Mn, in accordance with the present invention, is claimed in originally filed dependent claim 7.

Page 7, lines 30-32 of the specification discloses that when the upper limit of the Mn range of the present invention is exceeded, baking cracks and segregation are undesirably caused.

Therefore, Examples 4 to 18 of the technology of JP '945 do not disclose or suggest the steel pipe composition of the present invention defined in independent claims 1 to 4.

All of Examples 4 to 18 of Tables 1 and 2 of JP '945 disclose a tensile strength (TS) of less than 173.9 kgf/mm^2 (1700 MPa) except Example 11 which discloses a tensile strength (TS) of 180 kgf/mm^2.

However, the composition of Example 11 of JP '945 contains 2.50% Mn and 1.0% Mo which are outside the range of 0.5 to 1.60% Mn and not more than 0.5% Mo claimed by independent claims 1 to 4.

JP '945 does not disclose or suggest a steel pipe with the composition in accordance with the present invention having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater. JP '945 does not disclose or suggest how to make a steel pipe with the composition defined in independent claims 1 to 4 having a tensile strength (TS) of 173.9 kgf/mm^2 (1790 MPa) or greater because JP '945 does not disclose or suggest water quenching of a heat treated steel pipe having a steel composition in accordance with the present invention. JP '945 teaches normalizing or air cooling a heat treated steel pipe which does not have the defined composition of the present invention.

Note, Example 11 of JP '945 does not disclose or suggest a tensile strength of 183.5 kgf/mm^2 or greater (claim 2 - 1800 MPa); a tensile strength of 193.7 kgf/mm^2 or greater (claim 3 - 1900 MPa) or a tensile strength of 203.9 kgf/mm^2 (claim 4 - 2000 MPa).

JP '945 does not disclose or suggest the very high dislocation density of 10^{10} to 10^{14}/mm^{-2} of dependent claim 6. The very high dislocation density of the present invention is the result of water quenching and the very high dislocation density of the present invention results in the very high tensile strength (TS) and low yield ratio (YR) of the present invention. JP '945 teaches normalizing of a heat treated steel pipe.

U.S. Patent No. 5,374,322

As hereinafter discussed in detail, US '322 teaches that Cr (1.0 to 3.5%) is essential to the technology of US '322 in combination with air cooling. See Col. 6, lines 40-44.

The steel pipe of the present invention is water quenched and Cr is optional in the steel composition of the present invention. If Cr is present in the steel composition of the present invention, the maximum Cr is 0.5%.

The minimum, essential Cr of US '322 (1.0%) is 100% greater than the maximum Cr (0.5%) in the steel composition of the present invention.

The Office Action at page 6 cites Tables 1 and 2 of US '322 with respect to steels B1 (1726 MPa), B6 (1794.7 MPa) and B8 (1814.3 MPa).

With reference to Table 1, steel B1 contains 2.38% Cr; steel B6 contains 1.55 % Cr and steel B8 contains 1.95% Cr. The steel compositions of steels B1, B6 and B8 are very different than the maximum 0.5% Cr in accordance with the present invention. Steel B8 contains 1.92% Mn which is greater than the maximum 1.60% Mn in accordance with the present invention. With reference to Table 2, steels B1, B6 and B8 all have cooling rates expressed by °C/min of not more than 115°C/min. This is air cooling. Water quenching is cooling at a cooling rate of about 6000°C/min (100°C/sec) or greater.

Steels B1, B6 and B8 of US '322 are very different than the steel pipe in accordane with the present invention.

The Office Action at page 7 cites Tables 1 and 2 (should be Table 3) with respect to steel B10 (2059.47 MPa).

With reference to Table 1, steel B10 contains 2.97% Mn and 1.02% Cr. The steel composition of steel B10 is very different than the maximum 1.60 % Mn and the maximum 0.5% Cr in accordance with the present invention. Note that steel B10 also contains 0.48% C and 0.64% Si. The steel composition of the present invention contains a maximum of 0.30% C and a maximum of 0.27% Si. The steel composition of steel B10 of US '322 is unrelated to the steel composition of the present invention. With reference to Table 3, steel B10 has a cooling rate of 265 °C/min. This again is air cooling.

Steel B10 of US '322 is very different than the steel pipe according to the present invention.

Cr Essential

US '322 discloses a steel member having a composition containing 1.0 to 3.5% Cr as an essential component. US '322 discloses 1.0 to 3.5% to Cr at Col. 4, line 29, Col. 6, lines 40-50, and independent claims 1 and 4. In addition, all steel types of the examples of US '322 in Table 1 at Cols. 11-12 of US '322 disclose more than 1.0% Cr except steel type A13. Steel type A13 is identified as conventional steel (not the steel of the technology of US '322) which contains 0.68% Cr (greater than 0.5 Cr) and 1.86% Mn (greater than 1.60% Mn). The specification of US '322 states at Col. 6, lines 40-44:

> Cr is essential to the present invention in which a long pipe is quenched by cooling at a cooling rate corresponding to that of air cooling with distortions caused by quenching being greatly suppressed compared with those caused by water quenching.

In the present invention, Cr is an arbitrary component of the steel pipe composition, and if Cr is present in the composition of the steel pipe, the present invention limits the Cr content to not more than 0.5%. That is, the minimum essential Cr of US '322 (1.0% Cr) is twice as much as the maximum optional or arbitrary Cr (0.5%) permitted by the present invention.

Air Cooling

As noted above, US '322 at Col. 6, lines 40-44 clearly teaches air cooling and clearly teaches against water quenching. The essential Cr of US '322 is directly linked by the disclosure of US '322 to the cooling of a heat treated pipe by a cooling rate in a range provided by air cooling.

In contrast, the heat treated steel pipe of the present invention is water quenched. Water quenching of the present invention is directly related to the very high tensile strength (TS) and low yield rate (YR) of the present invention. The water quenching of the present invention results in the very high dislocation density of the present invention,

10^{10} to 10^{14}/mm^{-2}, which results in the very high tensile strength (TS) of the present invention.

US '322 teaches air cooling and teaches against water quenching throughout the specification of US '322. For example, US '322 states at Col. 1, lines 11-15:

> Instead of quenching following finish forming, normalizing can be applied to the steel member of this invention so as to achieve high strength and improved toughness, and therefore quenching distortion does not occur.

Normalizing is air cooling. The technology of US '322 is directed to air cooling and not water quenching.

US '322 further states at Col. 3, lines 38-57:

> It has been thought that it is advantageous to employ an as-quenched material in order to provide a steel member with a high strength at low costs. For this purpose it has been known to utilize water-quenching followed by tempering at a temperature as low as 200°C or less. However, water-quenching results in relatively large distortions which must be recovered at a later state. Furthermore, when the strength of the steel member is high, cracking and buckling, for example, occur with a degregation in accuracy in size during recovery of the distortions, making the recovery rather difficult from a practical viewpoint. Thus, from a practical viewpoint it is desirable that quenching be carried out by air cooling.
>
> According to the findings of the present inventors, it is possible to carry out quenching by air cooling when a steel composition is adjusted to a suitable one, particularly when the banite index is restricted to 0-50% and a steel member having a high strength and toughness with a low yield ratio can be obtained.

Col. 8, lines 8-9 of US '322 states that the steps within box in Fig. 1 are essential steps to the invention of US '322. Fig. 1 of US '322 disclose "Air Hardening" in a box. Thus, air cooling is taught as essential to the technology of US '322.

US ‘322 at Col. 5, lines 15-16 provides an equation (3) for calculating the cooling rate R. By calculation, the maximum cooling rate R is about 500°C/min. The maximum cooling rate actually used in the Examples of US ‘322 is at Table 5, Steel Type B10, cooling rate R = 300°C/min and Table 7, Steel Type B10, cooling rate R = 300°C/min. The maximum calculated cooling rate in the Examples of US ‘322 is at Table 3, Steel Type A10, and Table 5, Steel Type A10, calculate maximum cooling rate R = 498°C/min. Note: These examples are identified as “conventional”.

The present invention employs a water quenching cooling rate of about 6,000°C/min (100°C/sec) or higher. See specification page 9, line 37 to page 10, line 3. The water quenching of the present invention is essentially for achieving the very high tensile strength (TS) of the present invention. This has been previously discussed in detail. See specification page 9, line 14 to page 10, line 9. Table 2 at page 14 of the specification disclose cooling rates for the Inventive Examples of the present invention ranging between 150 to 200°C/sec (9,000 to 12,000°C/min).

US ‘322 clearly teaches air cooling of a heat treated steel pipe and clearly teaches away from water quenching of heat treated steel pipes. The cooling rates disclosed in US ‘322, in the parameter °C/min, are not comparable to the water quenching cooling rates, 6,000°C/min or higher, used in the present invention.

The water quenching of the present invention is required to achieve the very high tensile strength (TS) in combination with low yield ratio (YR) using the steel composition in accordance with the present invention.

<u>Examples of US ‘322 - Tensile Strength</u>

The examples of US ‘322 clearly show that US ‘322 cannot achieve a tensile strength (TS) of 173.9 kgf/mm^2 or greater (1700 MPa or greater) with a steel pipe having a composition as defined in independent claims 1 to 4.

The compositions of the steel pipes used in the examples of US '322 are listed in Table 1 of US '322. Note that all examples of US '322 disclose air cooling.

The following is a listing of steel pipes of US '322 having a tensile strength (TS) of 173.9 kgf/mm^2 or greater along with the composition of the steel pipe. The steel pipes are identified by Table number and "Steel Type".

TABLE 2 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
Al	177	2.66	1.08	-	
Bl	176	1.09	2.38	-	See C & Si
A4	186	1.53	1.89	-	
A4	205	1.53	1.89	-	
B6	183	1.35	1.55	-	
B8	185	1.92	1.95	-	

TABLE 3 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B10	210	2.97	1.02	-	See C & Si
A12	176	1.03	1.01	1.76	

TABLE 4 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B1	181	1.09	2.38	-	See C & Si
A4	182	1.53	1.89	-	
B6	177	1.35	1.55	-	
B8	180	1.92	1.95	-	
A9	174	1.62	1.54	-	

TABLE 5 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B10	207	2.97	1.02	-	See C & Si
A12	193	1.03	1.01	1.76	
B1	189	1.09	2.38	-	See C & Si

TABLE 6 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B1	178	1.09	2.38	-	See C & Si
A4	183	1.53	1.89	-	
B6	178	1.35	1.55	-	
B8	181	1.92	1.95	-	

TABLE 7 of US '322

Steel Type	TS	Mn	Cr	Mo	Note
B10	208	2.97	1.02	-	See C & Si
A12	176	1.03	1.01	1.76	

It is readily apparent that any example of US '322 that has a tensile strength (TS) of 173.9 kgf/mm^2 or greater has a composition that is outside the composition of the steel pipe of the present invention as defined in independent claims 1 to 4.

US '322 does not disclose or suggest the steel composition of the present invention. US '322 teaches that 1.0 to 3.5% Cr is essential in the steel composition. In the present invention, Cr is an arbitrary component in the steel composition, and if present, Cr is limited to not more than 0.5%.

US '322 teaches air cooling and teaches against water cooling. All the Examples of US '322 disclose air cooling. In the present invention, water quenching is required to achieve the very high dislocation density of 10^{10} to10^{14}/mm^{-2}. As previously discussed in detail, the very high dislocation density of the present invention is directly related to the very high tensile (TS) and low yield ratio (YR).

US '322 does not disclose or suggest a <u>water quenched</u> steel pipe having the composition defined in independent claims 1 to 4 and having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater. US '322 does not disclose or suggest how to make a steel pipe with the steel composition defined in independent claims 1 to 4 having a tensile strength (TS) of 173.9 kgf/mm^2 (1700 MPa) or greater because US '322 does not disclose or suggest water quenching of a heat treated steel pipe having a steel composition in accordance with the present invention. US '322 teaches air cooling a heat treated steel pipe which does not have the defined steel composition of the present invention.

US '322 does not disclose or suggest the very high dislocation density of 10^{10} to 10^{14}/mm^{-2} of dependent claim 6. The very high dislocation density of the present invention is the result of water quenching and the very high dislocation density of the present invention results in the very high tensile strength (TS) and low yield ratio (YR) of the present invention. US '322 teaches air cooling of a heat treated steel pipe and teaches away from water quenching.

<u>SUMMARY OF PATENTABILITY</u>

In view of the reasons set forth in the foregoing, it is submitted that amended independent claims 1 to 4, and all claims dependent thereon, are patentable over Japan No. 6-179945. JP '945 does not disclose or suggest a water quenched steel pipe having the claimed composition in <u>combination</u> with the claimed tensile strength (TS) of amended independent claims 1 to 4.

In view of the reasons set forth in the foregoing, it is submitted that amended independent claims 1 to 4, and all claims dependent thereon, are patentable over U.S. Patent No. 5,374,322 to Okada et al. US '322 does not disclose or suggest a water quenched steel pipe having the claimed composition in combination with the claimed tensile strength (TS) of amended independent claims 1 to 4.

Dependent claim 6 is further patentable because neither JP '945 nor US '322 disclose or suggest the high dislocation density of 10^{10} to $10^{14}/mm^{-2}$ of dependent claim 6. The high dislocation density of dependent claim 6 is the result of water quenching and is directly related to the high tensile strength (TS) of the present invention. JP '945 and US '322 teach air cooling.

Dependent claims 9 and 14 are further patentable because neither JP '945 nor US '322 disclose or suggest 95% or more martensite in the microstructure of the steel pipe.

Dependent method claims 11 to 14 are further patentable because they all expressly require water quenching. JP '945 and US '322 both teach air cooling.

CONCLUSION

In view of the present amendment, and the foregoing remarks, it is submitted that the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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